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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 164.

B. T. GALLOWAY, *Chief of Bureau.*

PROMISING ROOT CROPS FOR THE SOUTH.

I.—YAUTIAS, TAROS, AND DASHEENS.

BY

O. W. BARRETT,

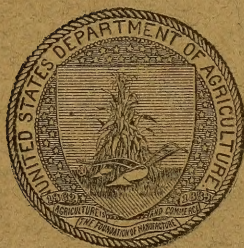
PLANT INTRODUCER, OFFICE OF FOREIGN SEED
AND PLANT INTRODUCTION.

II.—AGRICULTURAL HISTORY AND UTILITY OF THE
CULTIVATED AROIDS.

BY

O. F. COOK.

ISSUED FEBRUARY 5, 1910.



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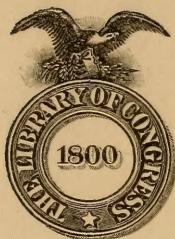
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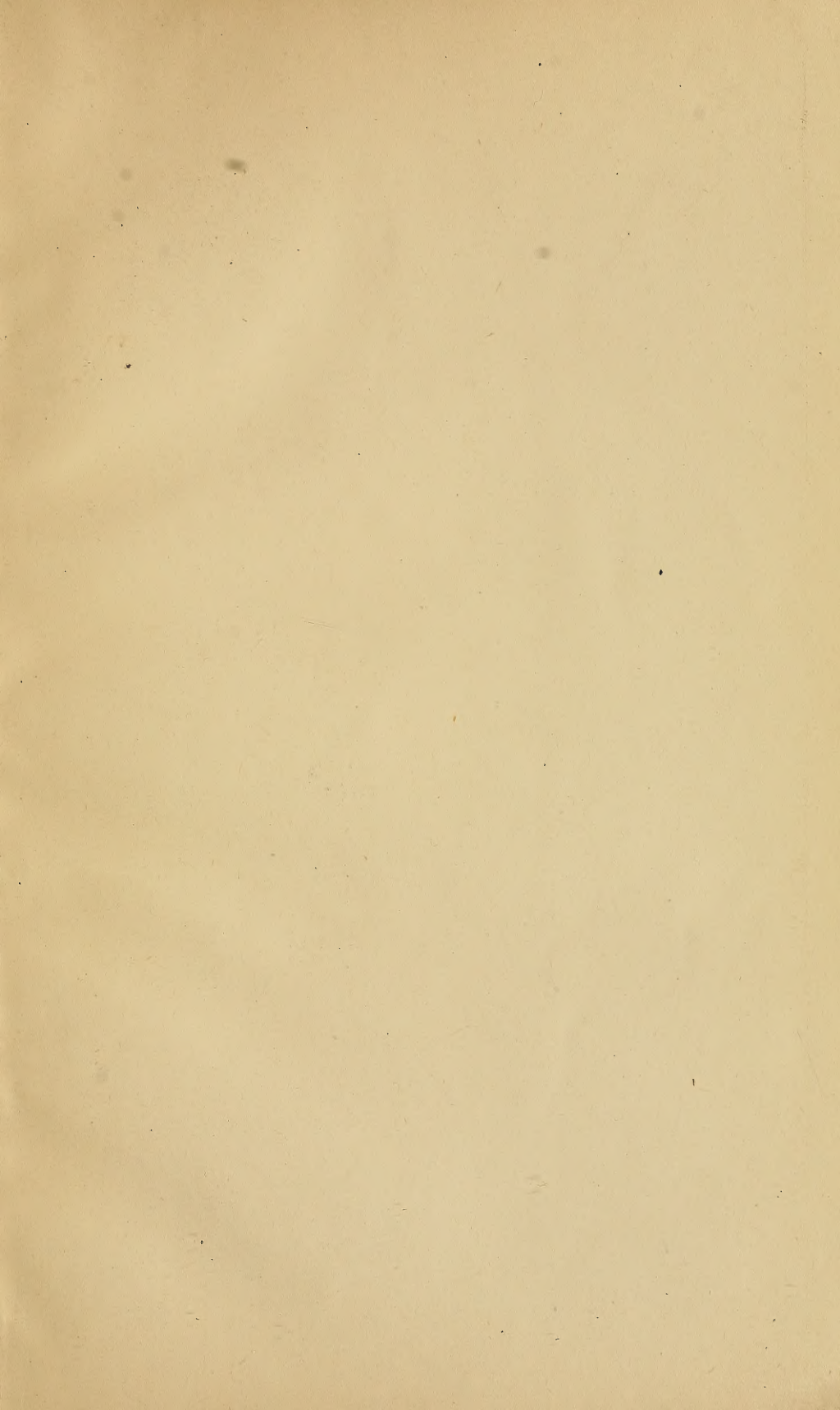


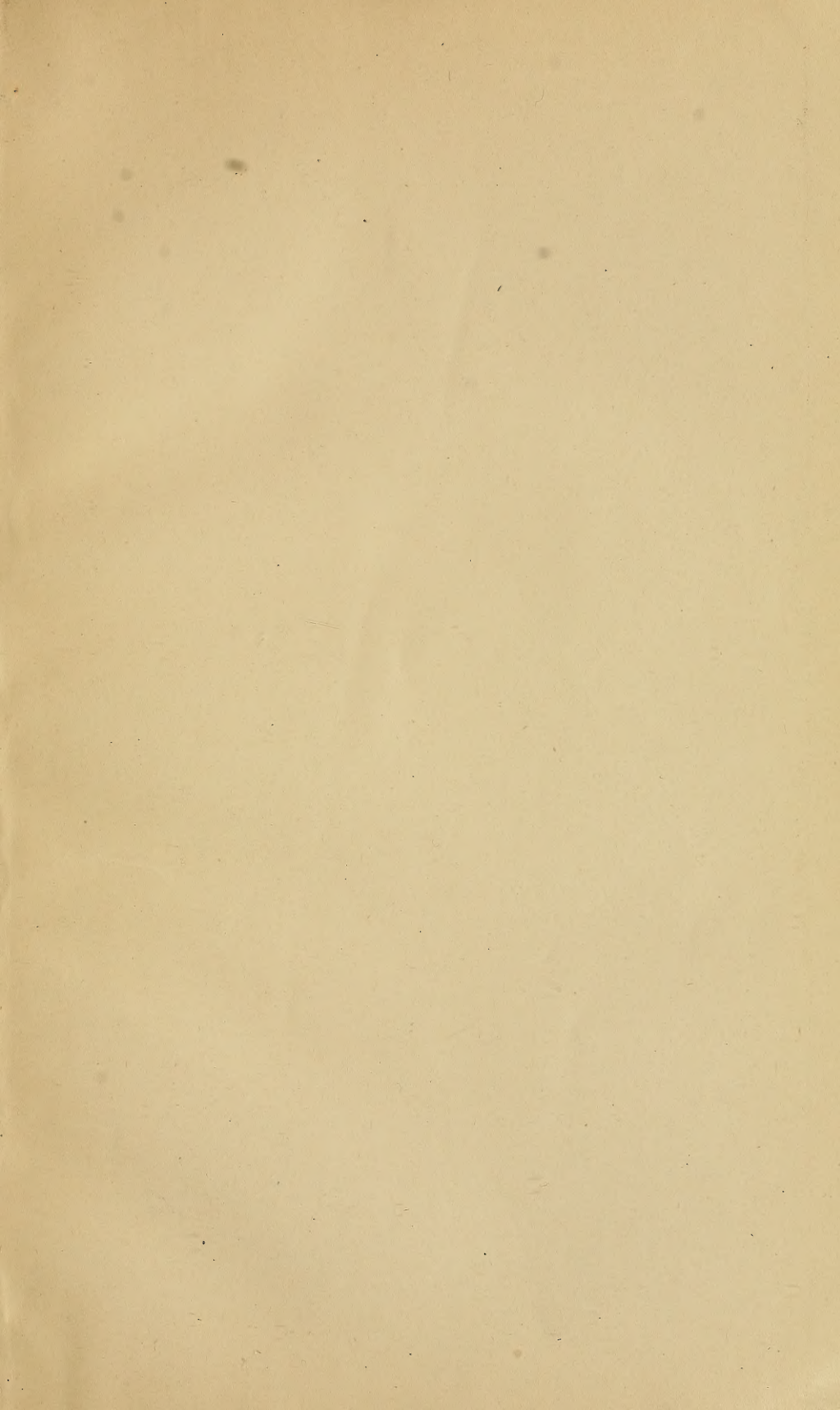
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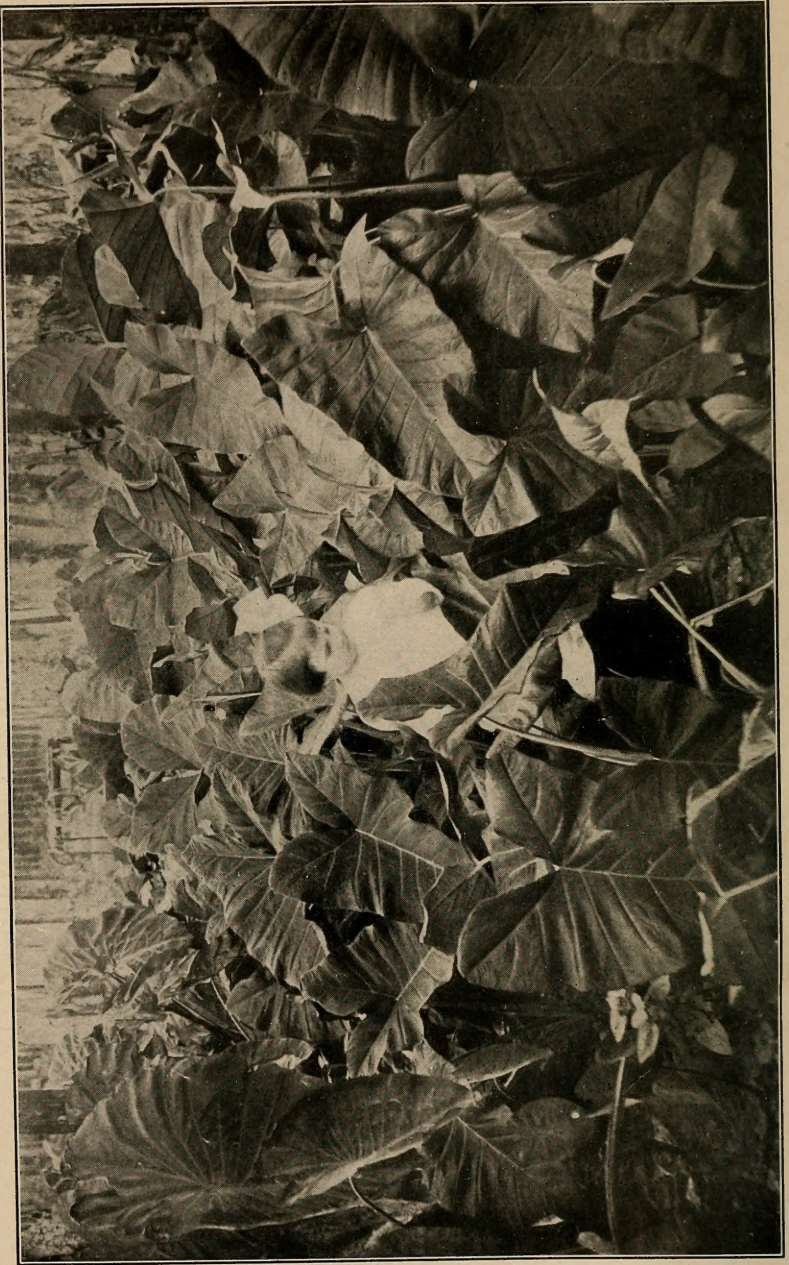
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A COLLECTION OF YAUTIAS (*XANTHOSOMA* spp.) GROWING AT GOTH, FLA.

U. S. DEPARTMENT OF AGRICULTURE.

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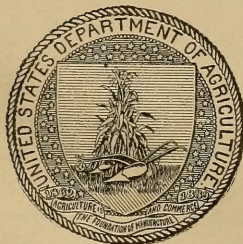
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D.C., September 15, 1909.

SIR: I have the honor to transmit herewith a manuscript entitled "Promising Root Crops for the South," consisting of two papers, "Yautias, Taros, and Dasheens," and "The Agricultural History and Utility of the Cultivated Aroids," and to recommend that it be published as Bulletin No. 164 of the Bureau series. These papers have been prepared by Mr. O. W. Barrett, formerly Plant Introducer, Office of Foreign Seed and Plant Introduction, and Mr. O. F. Cook, Bionomist, with a view to publication.

Mr. Barrett, who recently resigned his position in this Bureau to take up the organization of a department of agriculture in the colony of Portuguese East Africa, both before and after his connection with the Department of Agriculture, spent much time in investigating the possibilities of a group of plants that has been almost completely neglected by plant cultivators unfamiliar with the Tropics—yautias, taros, and dasheens. These root crops have formed the staple food of such native races as the Hawaiians in the Pacific, and they have played important rôles in the agriculture of China, Japan, and the Malay Archipelago; in fact, taking the Tropics as a whole, they are among the most important of all root crops.

Mr. Barrett has long believed that the yautias, dasheens, and other members of the group belonging to the family Araceæ could be cultivated with profit in the southern United States, and in order to find out what might be expected of the different varieties in this country, he assembled a large collection from different parts of the world. His practical experience with similar collections in Porto Rico encouraged him to recommend these as new root crops for the South.

This report was prepared rather hurriedly before Mr. Barrett's departure for East Africa. It contains the information which Mr. Barrett had collected regarding the different species and varieties, and its object is to enable persons unfamiliar with the plants to distinguish the different sorts, some of which are likely to be much more valuable than others.

A general chapter on the agricultural history and utility of the cultivated aroids has been prepared by Mr. O. F. Cook, who has been acquainted with these plants in tropical countries.

The collection of varieties of cultivated aroids assembled by Mr. Barrett is now being propagated at Gotha, Fla., in cooperation with Mr. H. Nehrling, and as soon as a sufficient stock of the different varieties is on hand small experiments with them will be started at different places in the South.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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PROMISING ROOT CROPS FOR THE SOUTH.

I.—YAUTIAS, TAROS, AND DASHEENS.

By O. W. BARRETT, *Plant Introducer, Office of Foreign Seed and Plant Introduction.*

INTRODUCTION.

For many years the lack of a wet-land root crop has been felt throughout the South Atlantic and Gulf States. In view of the fact that some 40,000 acres in the Carolinas and Georgia have been fully abandoned, with at least half as much ground that is only planted once in two to four years on account of the decreased profits in rice culture in that section, an effort has been made to find profitable crops which may be grown in the rich soils of the coast-plain area of both of the regions mentioned, which are too wet for profitable potato culture.

The recent increase of interest in starch roots, which may be utilized in the production of alcohol as well as for stock feeding, has lent a still greater importance to this question.

With one or two exceptions the root crops discussed in the following pages are practically new to this country and come from the Tropics. However, their crop season is sufficiently short to allow of their maturing in ordinary seasons before the advent of killing frosts; in fact, one or two of the varieties have been successfully grown with a fair yield as far north as central New York.

These crops comprise salad plants, table tubers, stock-feed tubers, starch roots, and varieties adapted for the manufacture of meal, alcohol, etc.

GENERAL DESCRIPTION OF YAUTIAS, TAROS, AND DASHEENS.

The economic aroids of the world have received very little attention outside of a few tropical countries, yet some of them bid fair to become of great commercial importance within a few years, for the following reasons: They are adapted to soils which are too wet for other root crops, such as sweet potatoes and cassava; they grow rapidly if given a fairly rich soil and a fair amount of moisture; they yield

heavily, in some cases two to four times the average yield of potatoes (the Rolliza yautia^a has yielded when moderately fertilized, with ordinary cultivation, at the rate of 15 tons of edible tubers, besides 5 tons of rootstocks suitable for stock feeding or starch manufacture); their keeping qualities are in most cases excellent, whether kept in the ground in situ or in a dry place in bags; and they are resistant to insect and fungous pests.

The yautias (see Pl. I), or, as some varieties are called in the British West Indies, taniers, are perhaps more important from the commercial point of view than either the taros or the dasheens. These three types of plants occur throughout the world in from 100 to 200 varieties.

The yautias, or taniers, belong to the genus *Xanthosoma*, and by far the greater number of forms are included in the species *X. sagittifolium* Schott. (See Pl. II, B.) The taros have long been known under the name *Colocasia antiquorum esculentum*; unfortunately, the yautias have been almost always, up to the beginning of the twentieth century, included under this name. The dasheens are tuberous-rooted taros, usually of dwarf habit (see Pl. III, B, and Pls. IV and V), and though it is uncertain to what species they belong there is no doubt whatever of their close kinship with the true taros. (See Pl. III, A.) The alocasias (see Pl. II, A) of the Orient and South America resemble the xanthosomas, but can usually be readily distinguished by their leaf, as well as their root, characters. The genera *Xanthosoma*, *Colocasia*, and *Alocasia* constitute almost the only economic plants in the subfamily Colocasieæ.

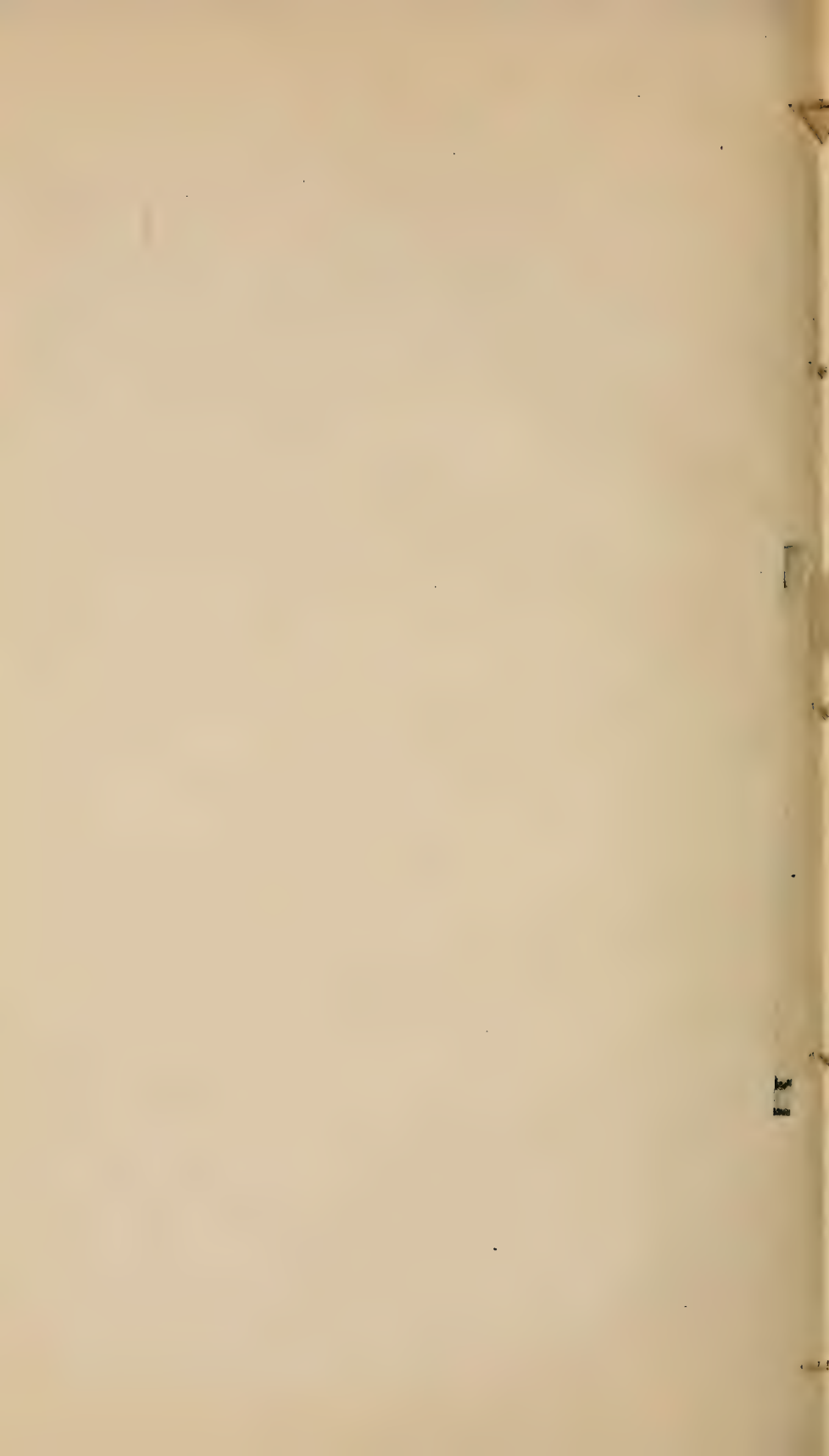
The general aspect of the plants belonging to this group is that of the so-called caladium, or elephant-ear, which has become popular as an ornamental during the past two or three decades. They are succulent, stemless plants, although some varieties produce a rhizome, or main rootstock, 2, or even 4, feet in length, the greater portion of which may be above the surface of the ground. The leaves arise from the tip of this rootstock or from its offsets or tubers. The leaf stem ranges from 1 to 8 feet in height; it is usually grooved near the middle, forming a sinus which at its lowest extremity is wrapped about the tip of the rootstock. Most varieties seldom or never produce flowers, and none of the cultivated forms have been observed by the author to produce seed under any circumstances. In fact, the yautias are considered the oldest cultivated crop in the world—and probably the only one, with the exception of the highly cultivated taros—which does not ripen seed under favorable conditions.

The leaf blade of the yautia is always sagittate, or arrow-shaped, i. e., the sinus at the broad base is open; exposing the attachment of

^a Pronounced yow-tee'-ah.



LEAF AND ROOTSTOCK OF THE ALOCASIA AND OF THE YAUTIA.
A, Sagittate leaf, with leaf sinus nearly closed, and rootstock of the alocasia; B, sagittate leaf, with leaf sinus open, and rootstock, surrounded with tubers, of the yautia.



the petiole (see Pl. II, *B*). The shape of the blade is more or less triangular, with the retroceding basal lobes more or less rounded on the side toward the leafstalk. In the dasheens and taros, however, the blade is peltate, or shield-shaped, i. e., the petiole is attached to the under side of the blade, usually about half way between the center and the basal margin (see Pl. III); the tip may be rounded or prolonged into a sharp angle. A more or less pronounced marginal vein runs just inside the entire edge of the leaf, connecting the tips of the side veins and opening by large pores on to the margin itself; frequently in sunshine immediately after rain there is a superfluity of water in the plant, and this is reduced by the discharge of drops through these pores—a phenomenon known as “weeping,” which is rather common among the aroids.

The entire plant of both the taro and the yautia is filled with laticiferous ducts containing a yellowish juice, which upon exposure rapidly thickens and turns brownish, forming a viscid gum. The true sap indelibly stains white cloth a reddish brown.

The tuber, which is morphologically merely a specialized horizontal branch of the more or less nearly vertical rhizome, varies in shape from a very slender root-like body, thickened toward the apex, to a nearly spherical form, the average shape, perhaps, being obovoid. The attachment may be weak, as in the case of the best types, the tubers of which may be readily snapped off from the central root-stock by a quick shake with the hand, or they may be strongly attached close about the parent root. The tubers are usually covered with a fibrous bark, especially near the apex. The color of the exterior is almost always, whether of the genus *Xanthosoma*, *Colocasia*, or *Alocasia*, a deep brown; the inner skin, however, may be white, rose, green, or purple, which shows particularly about the tip. The interior of the tuber is usually white or creamy white, but in some types it is yellow, orange, rose, or even purple. This feature is especially of interest when three or four sorts of as many colors are served together on the table.

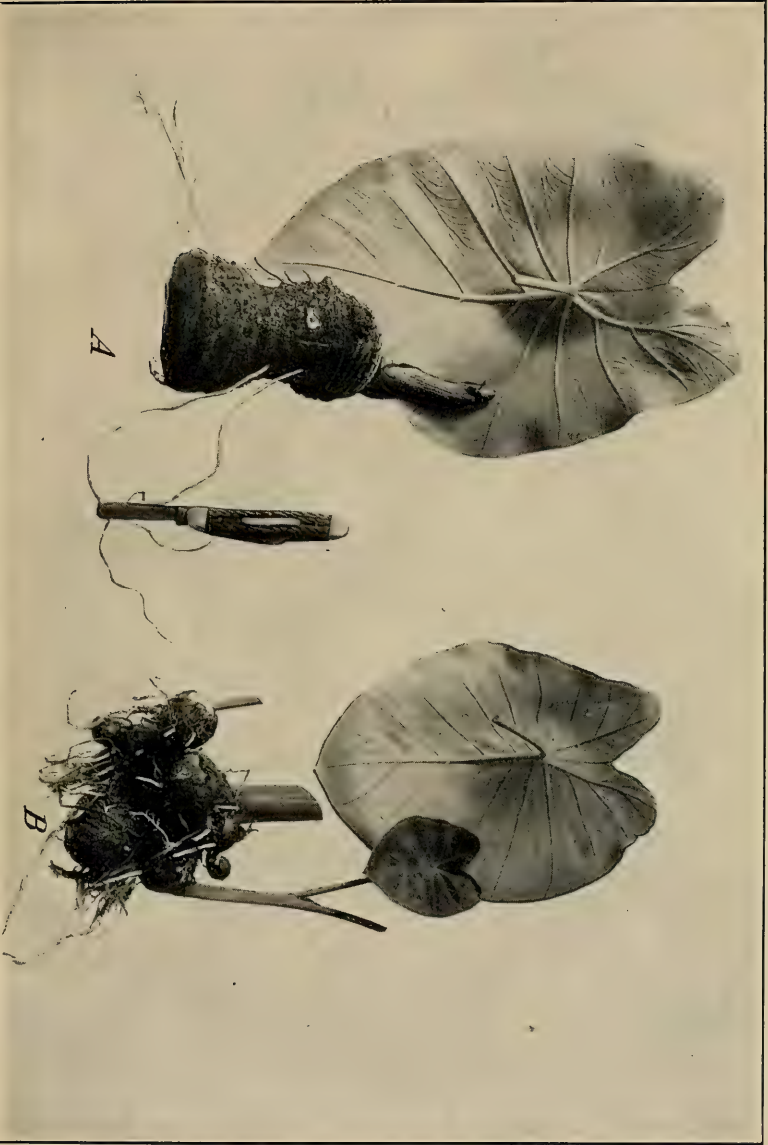
Both the rhizome and the tuber bear more or less prominent buds, or “eyes,” from which shoots may sprout under favorable conditions. The color, shape, number, etc., of these eyes upon the tuber vary constantly with the variety and are of considerable importance in distinguishing closely related forms. The rhizome is marked with distinct rings around its upper and thicker portion, which mark the axils of fallen leaf bases; just above these leaf scars are numerous small eyes, which seldom develop, whereas the lower portion of the rhizome bears another type of buds which may develop into tubers or, if exposed to light and air, into offsets and side shoots. The tuber also possesses eyes, or suppressed buds, which vary greatly in

character, according to the variety of the plant. They are usually naked and irregularly situated.

The roots of the tuber are usually few compared with those of the rootstock. As in most aroids, the roots of the plants of these three genera are coarse, but rather long; they vary from white to red, are somewhat brittle, and contain comparatively little of the milky latex which fills most of the other organs of the plant. None of these plants are deep-rooted.

The flowers appear in palmate clusters from the axil of the leaf. The peduncles, which are about one-third of the length of the petioles, are more or less adherent or connate toward the base. Seldom more than one flower in a cluster is open at a time. At the moment of flowering, the peduncle stands erect; immediately upon the partial opening of the flowerets upon the spadix the peduncle withers and falls, though rarely the spathe and the spadix decay before the peduncle finally shrivels. As before stated, however, the flower buds seldom open and are usually discovered in a semidecayed condition in the axil of the leaf. The flowers of related species of plants are snail-pollinated; no snails, however, have been noted by the writer in the flowers of any species of either of these three genera. The few species of wild or semicultivated sorts which occasionally attempt to produce seeds are probably insect-pollinated. The odor from the spathe is usually pronounced and varies from an unpleasant pungent aroma to a nauseous perfume. The spathe inclosing the spadix, which bears the minute flowers, is usually green at the base and creamy white or yellowish red in its limb or upper portion, which may be erect or bent at right angles to the spadix. The pistillate or basal portion of the spadix is thicker and much shorter than the staminate extremity; the spadix in these genera is always straight. In the taros the extreme tip of the spadix is sterile. In the case of some of the yautias, the spathe may barely exceed the tip of the spadix, whereas in some of the taros it may be prolonged to about twice the length of the spadix; it may be open, like that of a caladium, in some of the yautias, or it may be strongly twisted into a cornucopia-like roll, as in some of the taros.

The name yautia is an Arawak word which was in common use in the Greater Antilles at the time of the arrival of the Spaniards. The meaning is probably "place of (ya') the hutia (or spiny rat, *Capromys* sp.)," which was formerly very abundant in tropical America and which fed upon roots and fruits. The origin of the name tanier is unknown. The "r" is usually not pronounced in the British West Indies, and the spellings "tannia" and "tania" are frequently seen. Eddo is probably an African word synonymous with taro, but frequently applied to the tanier. Coco is another term applied to the



LEAF AND ROOTSTOCK OF THE TARO AND OF THE DASHEEN.

A, Pelate leaf and tuberless rootstock of the taro. B, pelate leaf and rootstock, surrounded with tubers, of the dasheen.

yautia in the British West Indies. Malanga is the Arawak name for taro, and is still current in Cuba for both yautias and taros. In Panama the yautia is called by the Indian (San Blas?) name of otó, while in Mexico it passes under the names of quequeste, tekixcamote (probably a mongrel Indian and Spanish word), rejalgar, colomo, lampaza, and macal.

Since the yautias have been only very recently introduced into the Eastern Hemisphere, there are of course few native names in that region. However, the local names for the taro varieties are exceedingly numerous and complicated. Probably as many as 100 more or less distinct forms of the taro and of the closely related dasheen are now extant; many varieties have probably been lost on account of the radical changes in habits of the aborigines in the Pacific islands during the past few decades. The locality in which the cultivation of the taros began appears to be Polynesia, though this is not definitely settled. A number of varieties have been cultivated for many centuries, if not for thousands of years, in China and Japan. There is not much doubt, however, that all of the yautias originated in tropical America. The alocasias appear in South America, western Polynesia, the East Indies, the Malay Peninsula, and India. There appears to be no local name which is sufficiently common or distinctive to permit of its use in this work.

GENERAL CULTURE.

The planting of yautias, taros, and dasheens should be begun as soon as danger from frost is over, for they require six months or more to mature.

The plants may be set in rows for convenience of cultivation, though in the case of very wet lands, where horse tools can not be used and where the weeds are killed by allowing the water to stand at intervals, a close, haphazard method, as practiced in the Orient, is advisable.

The distance between plants depends largely upon the variety planted. Most varieties of yautias and taros require from 1 to 2 square yards of surface for their proper development; the dasheens, being of lesser growth, require only from one-half to three-fourths as much space. In rich alluvial soil, 5,000 to 10,000 plants may be set per acre. If planted in fairly dry soil, close planting in rows about 3 feet apart is recommended; this will allow cultivating the young plants with a horse hoe or cultivator.

Both the tops of the old rootstocks and the tubers themselves may be used as "seed." Even sections of the old rhizome of sufficient size for each chunk to bear two or more buds may be utilized. The "head," or top, of the rhizome, which is the preferred portion for

planting, is prepared by cutting off the tip of the old stem, leaving $\frac{1}{2}$ to $1\frac{1}{2}$ inches of the leafless portion and about 4 inches of the basal portion of the rolled-up leafstalks. The dead bases of the petioles, if any, are peeled off from this head until fresh tissue showing the dormant buds is visible. In setting, the tip of the cylinder of petioles is left just above the surface of the soil; thus the portion of the rootstock is protected from overheating by the sun. Care should be taken, however, to allow no stagnant water to settle in the plant hole, as this would very likely cause rotting of the rhizome before the roots could be formed. In fact, sour soil containing stagnant water is of course injurious to any of these plants, especially when young. After growth has started, however, plenty of water moving through the soil is undoubtedly advantageous.

FERTILIZERS.

Like all root crops giving heavy yields, yautias, taros, and dasheens require either a naturally rich or a well-manured soil. Potash seems to be the element demanded. At the Porto Rico Experiment Station unfavorable results were obtained by the author with chemical nitrates and phosphates. Ordinary stable manure gave the best yield. Well-rotted coffee pulp on ordinary soil gave a yield of 12.4 tons per acre. Soil which can frequently be flooded will probably require no manure whatever.

HARVESTING.

The usual method of harvesting yautias, taros, and dasheens is by hand pulling, supplemented by the use of a pick or a mattock. The bundle of leafstalks of the mature plant is grasped in both hands, and if the soil is moist or sandy one strong pull usually brings up the entire root system; if some of the tubers break off from the rhizome and remain in the ground, they are readily brought out with a blow or two with a hoe. If the soil is packed, it may be necessary to loosen it, at least on one side of the hill, with a hoe before lifting the plant—after the manner of removing cassava roots.

The treatment of the tubers and rhizomes after removing from the soil depends upon the use to which they are to be put. Of course, as much earth should be removed as possible before hauling from the field; this can be accomplished in dry weather by simply leaving the roots in loose, shallow piles upon the soil surface.

In the West Indies "castration" of the tubers is sometimes employed; this consists in digging about the rootstock and removing mature tubers by means of a knife or even with the fingers. This process is of course not advised in this country, except where tubers are required for the table early in the season. Where the plants may



BASE OF A DASHEEN PLANT, SHOWING TUBERS.

be allowed to continue growth for eighteen to twenty-four months and where this method of castration is employed, it is undoubtedly possible to take as much as 30 tons of tubers from one acre in that time.

YIELD.

While single yautia plants may yield as high as 6 or more pounds of tubers to the hill, the average for common varieties in ordinary soil may be reckoned at 2 to 4 pounds per hill. The yield of the taro should be about the same as that of the yautia. The yield of the dasheen is 50 to 75 per cent of that of the yautia; however, in favorable conditions the yield may amount to 4 or 5 pounds per hill, which should give 15 or more tons of roots to the acre. The yield for alocasia varieties has never been calculated, but will probably be found to be somewhat lower than that of the yautias.

STORAGE.

If kept dry after being harvested, the roots resist decay fairly well; small packages of tubers can easily be kept six months in a dry atmosphere without losing much of their vitality. If left in the ground in situ they also keep fairly well and have been carried through the winter season in South Carolina, Florida, Alabama, and Texas. The roots, whether tubers or rhizomes, should be stored in such manner as to guard against frost, decay from dampness, and damage from animal pests.

DISEASES.

All parts of the plants, with the exception of the parenchyma of the leaf, are filled with a thick juice which appears to protect the plants against the attacks of insects, fungi, and bacteria under ordinary conditions. However, there are two or three forms of decay in the tuber which are due partly to fungous and bacterial infection and partly to physiological causes; these decays seldom affect any except tubers and rootstocks which have lain dormant in the soil or which were slightly infected with the germs at the time of harvesting.

During drought the margin of the leaf blade sometimes shows large, roundish patches of dead tissues.

A white mycelial growth is frequently found on the surface of tubers and rhizomes. On the former the white threads seem to do no injury whatever, but about the top of the rootstock there are frequently to be found patches of agglomerated hyphæ beneath which the cortical tissue is partially destroyed. The bases of the leaves are rarely attacked, but in a few cases have been noted as affected by a soft rot, probably caused by infection of this white mycelium. Heads or tubers showing any trace of the yellowish or whitish areas

caused by fungous mycelium or any patches of soft-rot should be discarded in planting. The brownish fibro-vascular bundles frequently seen in tubers and rootstocks of material which has been kept for some time after maturing are to be looked upon with suspicion, though their presence is not necessarily a proof of the existence of a fungous disease.

COMPOSITION OF TUBERS.

The following passage is quoted from Bulletin 6 of the Porto Rico Agricultural Experiment Station ^a:

Analyses of two samples of yautia have been made at the Maine Experiment Station, and the results given below are quoted from unpublished material. A white variety contained 85.9 per cent edible portion and 14.1 per cent refuse, i. e., parings. A yellow variety contained 76.9 per cent edible portion and 23.1 per cent refuse. In the preparation of ordinary Irish potatoes and sweet potatoes for the table, the edible portion constitutes on an average 80 per cent and the parings or refuse 20 per cent of the tuber. The following table shows the composition of the two varieties of yautia analyzed, calculated to a uniform basis of 70 per cent of moisture, and includes for purposes of comparison the composition of Irish potatoes and sweet potatoes:

Composition of yautias and potatoes.

Yautia and potato.	Water.	Protein.	Fat.	Total carbohy- drates.		Ash.	Fuel value per pound.
				Sugar, starch, etc.	Crude fiber.		
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Calories.</i>
White yautia.....	70.0	1.7	0.2	26.3	0.6	1.2	529
Yellow yautia.....	70.0	2.5	.2	26.1	.6	.6	538
Irish potato.....	78.3	2.2	.1	18.0	.4	1.0	385
Sweet potato.....	69.0	1.8	.7	26.1	1.3	1.1	570

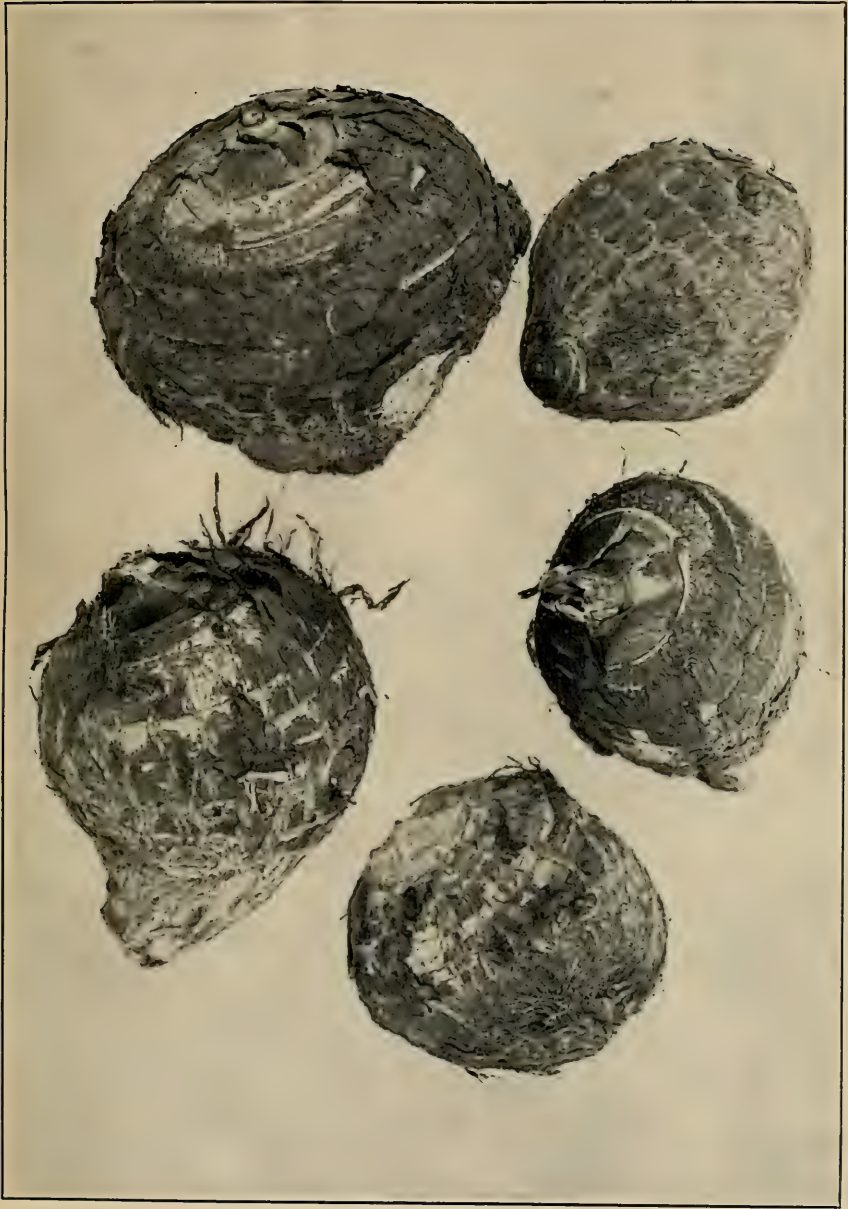
The analyses show that yautias do not differ materially in composition from the potatoes. As is the case with potatoes, carbohydrates constitute the chief nutritive material. An examination of the yautias shows that the principal carbohydrate present is starch.

STARCH.

Yautia varieties range from about 20 per cent to 30 per cent of starch. Taro varieties are ill adapted to starch manufacture for two reasons: The starch grain is only about one-fifth the size of that of the yautia ($1\ \mu$ to $3\ \mu$,^b see Pl. VI, figs. 1 and 4), which prevents the rapid settling of starch grains in water, and the rhizome of all taros examined thus far contains a gummy substance which renders the water in which the ground or grated root may be suspended of such a

^a Barrett, O. W. The Yautias, or Taniers, of Porto Rico. Bulletin 6, Porto Rico Agricultural Experiment Station, U. S. Dept. of Agriculture, 1905, p. 23.

^b $1\ \mu = 1/1000$ millimeter, or about $1/25000$ inch.



TUBERS OF A DASHEEN GROWN AT GOUGH, S. C.
(Seven-eighths natural size.)

viscous nature that the starch grains are prevented from sinking to the bottom. *Alocasia* starch (see Pl. VI, fig. 2) has been but slightly investigated thus far, but though the starch content of *alocasia* roots is somewhat less than that of *yautias* the gum contained is probably much less than in the case of the taro.

The size of the starch grain varies considerably in different *yautias*, and is probably affected to a greater or less degree by the soil conditions, seasons, etc., in which the starch was produced. The size of the starch grain in the *dasheen* and the taro does not seriously interfere with the use of these roots as alcohol producers or as a source for stock feed, flour, etc.

FLOUR, MEAL, ETC.

Flour made by grinding dry slices of peeled *yautia* tubers is considered in the West Indies more nutritious and fully as palatable as the famous cassava, or "bammy," cakes; it contains rather less fibrous matter and no trace of the rather dangerous hydrocyanic acid, which occurs even in the sweet cassavas under certain conditions.

Taro flour has been on the market for several years, and is said to form a very easily digested food for invalids, infants, and persons in whom the digestive function is weak. It may be mentioned that the principal food of the Hawaiian race was poi, made from taro roots, and in their language there was no expression whatever for indigestion. Flour made from the red or yellow tuber variety of *yautias* should prove an attractive article in the northern markets. About 70 per cent of the peeled tuber is water; thus 10 pounds of tubers, net weight, yield after 3 hours' drying about 3 pounds of flour. This flour will keep indefinitely without becoming musty if protected from moisture.

USES.

Yautia tubers boiled form a large part of the diet of the laboring classes in tropical America; in fact, the *yautia* ranks third in importance among the root crops in many countries of that region. The fried tubers enter into many dishes on the planters' tables. In some places, especially Jamaica, the larger tubers are baked and served like baked potatoes. The taro rootstocks may be eaten either boiled or baked, but are frequently served as purées and used in thickening soups and stews. None of the *alocasias*, with possibly a few exceptions, are suitable for table use.

In boiling, the thin skin should be previously removed. This skin may be left on in baking or roasting and may even be eaten along with the interior, as in the case of the true yams. When baked, the mealiness and peculiar flavor of the *yautia* are brought

out much better than in any other method of cooking. The tubers of some yautia varieties are decidedly firm, even when thoroughly boiled; in fact, some of the varieties are best served mashed and made into small cakes, or croquettes, for otherwise—unless eaten at once while hot—the hard texture may be somewhat objectionable. The water in which the tubers are boiled should of course be well salted.

An excellent method of serving yautia tubers is as follows: Mash the thoroughly boiled tubers, then add milk or eggs and grated cheese; this mixture should be made into small, thin croquettes and fried. Parboiling, cutting in thin slices, and frying is a native method in tropical America which brings out the characteristic flavor to good advantage. In fact, the yautia may be used in any way in which the common potato is used, and while there is very little difference in flavor among the many varieties of potatoes there is considerable variation in flavor, as well as great difference in color, among the yautia varieties.

The young leaves of both taros and yautias cooked as a salad are a valuable addition to our list of pot herbs.^a As compared with other greens, these leaves contain probably more nourishment, as well as flavor, because of the creamy sap contained in these plants, especially the yautias. The boiled leaves may be served either with a milk or cream sauce, or fried like cabbage or made into croquettes with eggs, cheese, and milk.

The Belembe yautia has a less rich but a more pronounced flavor, perhaps, than any other variety. The purple leaves of the *Violacea* type turn to a dull purplish color when boiled, resembling the purple-leaved cabbage. The petioles of some of the Japanese varieties are also cooked for greens, and in one case are said to be eaten raw. However, on account of the minute, needle-like crystals of calcium oxalate contained in the leaves, and to some extent in the outer portion of the tubers and rootstocks of both yautias and taros, cooking should always be carefully attended to. The *alocasias* contain a larger quantity of these crystals in the "blanket" portion of the roots than do either the taros or the yautias.

Few stock-feeding experiments have been carried out with either yautia or taro roots. At the Porto Rico Experiment Station yautias were fed to pigs with favorable results, except that when used as an unmixed ration it was believed there was a tendency to produce scouring.

^a Mr. H. F. Schultz, horticulturist in charge of the Commission's vegetable gardens of the Canal Zone, has grown thousands of pounds of "yautia spinach" for the officers' mess, and it has proved a great success as served on their tables, taking the place of spinach when the latter could not be supplied. Mr. Schultz states that he finds it difficult to supply the growing demand for this tender and spicy vegetable.



FIG. 1.—STARCH GRAINS OF THE TARO.

(Magnified 200 diameters.)

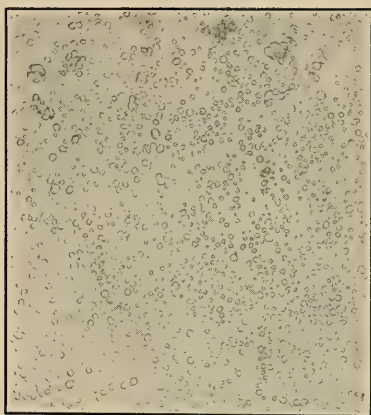


FIG. 2.—STARCH GRAINS OF THE ALO-
CASIA.

(Magnified 200 diameters.)

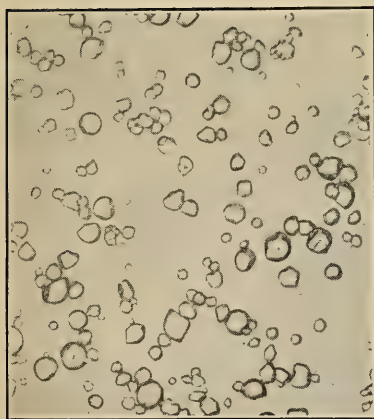


FIG. 3.—STARCH GRAINS OF THE
YAUTIA.

(Magnified 200 diameters.)

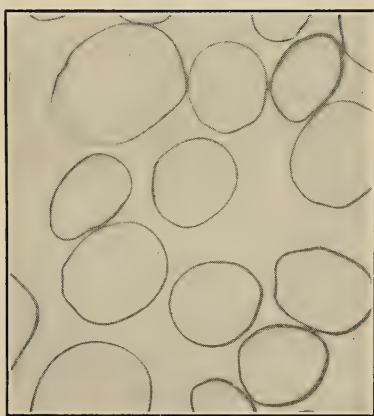


FIG. 4.—STARCH GRAINS OF THE CANNA
EDULIS.

(Magnified 200 diameters.)

No experiments have been made thus far regarding the commercial methods of obtaining alcohol from these roots. It is believed, however, that many varieties will prove superior to potatoes in this respect, and the fact that yautias can be grown in the wet lands of the Southern States, where neither cassava, sweet potatoes, nor potatoes can be grown, renders the need for further investigation along this line decidedly urgent.

YAUTIA VARIETIES.

The known cultivated forms of this most interesting class of economic plants may be grouped under the following eight sections.

THE ROLLIZA GROUP.

The Rolliza variety (S. P. I. No. 14471) is in many ways the best form yet tested. There are many slight variations, or at least geographical forms, of this variety, which may be described as follows:

Height 3 to 5 feet, with spreading petioles and triangular blades. The green petioles have a mauve line running along the more or less revolute sinus margin. The basal veins at the attachment of the petiole are always naked in mature leaves for one-half to 1 inch from the sinus. The tubers (Pl. VII) are comparatively large and regular in shape, i. e., nearly cylindrical, with the apex slightly larger and frequently somewhat bent upward; the eyes and roots are comparatively few; the interior is an even white throughout and the flavor when cooked is excellent. Flowers are almost never produced in this variety. Time for maturing, eight to eleven months, depending upon dryness of season and soil. Adapts itself more readily to various conditions than most other varieties.

This is the most widely distributed type of yautia, and is known to occur in Venezuela, Trinidad, Dominica, Porto Rico, Isle of Pines, Cuba, Santo Domingo, Mexico, British Honduras, and Surinam. Closely related varieties have been received from Ceylon (probably introduced from South America), British Guiana, and Colombia. The many forms of this variety differ in the amount of color in evidence upon the outer portion of the petiole, in the width and shade of the sinus margin stripe, in the vigor of the plant, etc. It is probable that extensive field tests of these forms would show that several, at least, have tubers with characters which make them readily interdistinguishable.

A Jamaica variety (S. P. I. No. 15397) very similar in appearance as to leaf and leafstalk, and even the root system, produces tubers having a tendency to come to the surface of the soil and with a distinct taro-like flavor when cooked; according to Mr. Nehrling they are sometimes found standing erect above the soil surface about the mother plant.

A variety which has been in the trade as *Alocasia marshalli* (S. P. I. No. 15401) is of unknown habitat, and though the tubers are scarcely distinguishable from those of the Rolliza the entire petiole is covered

with a glaucous, bluish bloom and stands more erect than in the type variety.

A variety from Jamaica (S. P. I. No. 15415) has a leafstalk reddish toward the base and with a wider maroon stripe on the sinus wing, while the midrib and the basal veins of the blade are reddish beneath.

Two other Jamaica varieties (S. P. I. Nos. 15406 and 15418) closely resemble the parent type, but the tubers of the former are smaller and more numerous, while the petiole of the latter is of a brighter green and has a more strongly colored sinus stripe.

A variety known in Porto Rico as the "Blanca" (S. P. I. No. 15419) has erect petioles and more slender rhizomes, which curiously enough contain numerous raphidian crystals which bar the rootstocks of this variety from the table, although the tubers are apparently free from this defect; this variety is supposed to endure more stagnant water in the soil than its sister sort, the Rolliza.

A variety from Honduras, via Florida (S. P. I. No. 17462), may belong to another type because of its yellowish tubers and the extra amount of color on the sinus wing and the base of the petiole.

A variety received from Singapore (S. P. I. No. 18384) also has a creamy white tuber and a leaf blade somewhat more shining than in the Rolliza. The origin of this variety is undoubtedly tropical America; this was received as *Alocasia indica*. A variety (S. P. I. No. 19271) cultivated in Texas as an ornamental proves to be quite distinct from Rolliza on account of the exceedingly slender tubers.

A variety which has been in the trade as *Alocasia javanica* (S. P. I. No. 19291) may perhaps belong to a distinct type; the tubers are numerous, clustered, of irregular shape, and white inside with greenish inner rind; there are also slight peculiarities in petiole and blade.

A variety (S. P. I. No. 20484) from Santo Domingo also has creamy white tubers. A variety in northeastern Mexico, the Lampaza (S. P. I. No. 17149), is entirely green with the exception of a narrow line on the sinus margin; another variety there, the Rejalgar (S. P. I. No. 20970), has a petiole reddish at the base and bluish in the middle, while the blade has a violet margin, and in the young leaf the veins are shaded red beneath; the natives do not cultivate this latter variety, but gather the young leaves and petioles for greens and to mix with their stews, while the tubers are also mashed and made into a gruel, according to Dr. Edward Palmer.

THE MANOLA GROUP.

The plants in the Manola section are characterized by the flatness of their leaf blades—in this resembling many of the alocasias, but the naked basal veins at the sinus make them xanthosomas. The varieties belonging to this type are usually of more dwarf size than



ONE OF THE BEST TABLE VARIETIES OF YAUTIA, THE ROLLIZA, SHOWING NUMEROUS TUBERS ATTACHED TO THE ROOTSTOCK.

those of the Rolliza section, and the tubers are variable. The plants are adapted to much drier soils and they withstand long periods of drought much better. This type appears confined to the island of Porto Rico.

The Manola yautia of Porto Rico (S. P. I. No. 15405) may readily be distinguished by its very flat, broadly triangular leaf blade and its comparatively short petioles, which are scarcely colored at all on the margin of the sinus wing. The color of the tubers varies inside according to their size and maturity from pale yellow to orange; the exterior is rough, with numerous small eyes.

The Gengibrilla yautia of Porto Rico (S. P. I. No. 15388) has a much more slender petiole, with less bluish glaucous coloring on the surface, but with considerable reddish maroon shading on the inside of the sinus wings. On account of the very slender tubers it is doubtful whether this variety can correctly be placed in this group, notwithstanding the flatness of the leaf blade.

A very rare variety discovered in the west end of Porto Rico and known there as the "Islena" (S. P. I. No. 15390) may be distinguished from the Manola by the large irregular blotches of reddish purple and maroon on the outside of the sinus wing. The tubers are normal in shape, but pinkish inside and of high quality.

THE AMARILLA GROUP.

Varieties in the Amarilla group are the most dwarf of all yautias, and though closely resembling the Rolliza varieties as to blade and petiole the very short and rough tubers which are of a yellowish or orange color inside distinguish them from those in the Rolliza section, while the concave or irregularly curved blade separates them from yautias of the Manola type. Varieties of the Amarilla type are known to occur in Cuba, Santo Domingo, Porto Rico, and Dominica, and they probably occur in some of the South American countries.

The Amarilla of Porto Rico and Cuba (S. P. I. No. 15387) has short petioles covered with a glaucous gray bloom, but without any purplish shading on the sinus margin. The tubers are short, small, very firm, yellow inside, and of very rich flavor; their keeping qualities are excellent when not affected with fungous diseases previous to harvesting. During the dry season the tubers may be left in the ground for weeks, or even months, and removed from time to time as required. While the yield is not so high as in some other types, the richness of the flavor and the good keeping qualities render it a popular variety.

A larger variety of the Amarilla type, the "Dominica," or "Samana," of Porto Rico (S. P. I. No. 15408), is distinguished by having a few blotches or stripes of a maroon color along the sinus margin, by its much more slender habit, and by the paler color of the leaf blade.

The tuber in some respects is the finest flavored and richest of all the varieties of yautias tested thus far. It should be generally cultivated, since it proves fairly productive and resistant to fungous attacks.

THE MARTINICA GROUP.

Most varieties of the Martinica section are strong growing, handsomely colored, and fairly productive. The petiole is usually striped, especially near the sinus. The leaf blade is usually dark in color; the tubers are of fair size, but short, rough, and beset with numerous small eyes; the interior is yellow or orange. The type of this section, the Martinica (S. P. I. No. 15385, probably introduced from Martinique), is sometimes known as the "Huevo," on account of the egg-shaped tubers; as the "Quintal," from its supposed maximum yield of 100 pounds per clump; and as the "Amarilla," from the bright-yellow color of the tubers. This plant, which has been known in the trade as *Xanthosoma maculatum*, is one of the most striking varieties when well grown; the petiole sometimes attains a height of 4 or 5 feet and is beautifully shaded with cream and rose on a green background, while along the sinus wings are irregular blotches of maroon and reddish brown. It is fairly productive, but there is a tendency to over-stooling, and for this reason it should be harvested as soon as the tubers are mature; if left in the ground like the Amarilla these tubers usually send up new shoots even during the driest weather. The tubers are perhaps more nearly cylindrical than in any other variety; however, they bear many roots and are firmly attached to the central rootstock. The color is deep yellow inside, and when cooked this turns to a deep olive or grayish yellow shade. The tubers are so rich that only a few ounces suffice for the carbohydrate portion of a meal. Like the tubers of the Amarilla, their firmness is a rather objectionable characteristic. Not only does this variety flower more frequently than any other, but teratological monstrosities have been noted in several instances, as, for example, double spathes, coherent peduncles, and distally flattened spadices. Unfortunately this otherwise highly desirable variety appears susceptible to fungous diseases and does not endure drought well.

The Orqueta (S. P. I. No. 15379) is an exceedingly rare variety which is confined to a small district of Porto Rico. The leafstalks are the palest of all the yautias, in some cases when grown in the shade being nearly white; there are always, however, a few faint streaks of maroon along the sinus margin. The leaf blade is also of a pale yellowish green color. The tuber is yellow or orange inside. This variety is inferior in point of hardiness and productiveness, but is of some use as an ornamental, and in moist, rich soils will yield a fair crop.

THE OTÓ GROUP.

Varieties of the Otó section have a general resemblance above ground, but the tubers are exceedingly variable in color. The petioles are always strongly colored, either reddish, bluish purple, or glaucous maroon; the whitish bloom common to most yautias is more in evidence in this than in the other sections already mentioned. The plants are usually of medium to large size, and though results of field experiments are lacking, there is no doubt that some of the varieties will prove of high value.

The so-called "Jamaica tanier" of Trinidad (S. P. I. No. 15383) has reddish brown petioles with a glaucous sinus wing, which becomes deep reddish purple along the margin, which is usually rolled inward. The midrib and basal veins are mauve-purple beneath, especially in young leaves. The rhizome is orange-yellow inside and the tubers are of a decided yellow shade.

A variety received from the Jamaica Department of Agriculture (S. P. I. No. 15403) resembles the one just mentioned as to blade and petiole characters, except that there is more of a reddish or scarlet tinge at the base of the leafstalks and along the sinus margin. However, the tubers are of a pronounced rose color and comparatively short, while the rhizome is of a pale-rose tinge throughout.

A variety received from Guatemala (S. P. I. No. 15804) is probably identical with the Jamaica of Trinidad, but appears to be more vigorous and prolific. A similar variety (S. P. I. No. 16947) from Kamerun, West Africa, differs from the two previous sorts in having white tubers. This variety was probably introduced from tropical America.

The Otó of Panama (S. P. I. No. 19715) has a reddish, very erect petiole with strongly reflexed sinus wings, marked with numerous purple lines; the blade is short, but the basal veins are less exposed than in most varieties. The tubers are of a beautiful rose shade.

A variety from Santo Domingo (S. P. I. No. 20488), similar to the preceding, has a pronounced bluish glaucous bloom on the leafstalks, and the pale flesh of the rhizome is marked with dark-purple lines along the fibro-vascular bundles.

THE VINO GROUP.

The varieties of the Vino section of yautias are usually dwarf or medium in size, with more or less coloring of the leafstalks and with pinkish or purplish tubers. The tendency to "sucker" is an objectionable feature. These yautias should be grown upon rich, moist soils and planted comparatively close. The flavor of the tubers, together with their unusual color, which is even more pronounced after cooking, renders them of high value for the table.

The Vino, or Punzera (S. P. I. No. 15377), of Porto Rico is apparently confined to the West Indies and is nowhere common. The leaf blade is of a dark-green shade with light-colored veins, and the petiole is stained purple along the inside. The tuber is distinctly flaky or "mealy" when baked, or even when boiled, and has a delicate nutlike flavor distinct from that of most other yautias. No record of the flowering of this variety has been obtained.

The Islena of the south side of Porto Rico (S. P. I. No. 15410) is the largest variety of this section and sometimes attains a height of 6 feet. This variety in blade, petiole, and tuber is very similar to the Vino.

Similar varieties have been received from Grenada and Santo Domingo; one from Haiti (S. P. I. No. 17703) has a dark-violet margin around the blade and the young leaf is stained maroon, except along the veins, while the sinus margin is irregularly marked. The rose-tuber form (S. P. I. No. 19778), called the "Tekixcamote," of Chiapas, Mexico; the red-tuber form (S. P. I. No. 20864), called the "Macal," of Tabasco, Mexico; and a variety having strongly colored petioles (S. P. I. No. 17463; see Pl. VIII, fig. 2), from Honduras, belong in this section, but have not been sufficiently studied.

THE SENTEH GROUP.

The three varieties of the Senteh type have been received only from Java; theoretically, all of the East India xanthosomas were introduced from tropical America, but it is believed that the American prototypes have in this case become extinct in the Western Hemisphere.

The Senteh (S. P. I. No. 17236), which was received as *Alocasia macrorrhiza*, may readily be distinguished from all but one of the other yautias by the strongly contrasted dark-maroon or bronze-purple blotches along the sinus wing and on the sides, and even the back, of the petiole, especially toward the base. Although the young petiole is sometimes nearly white, in a few cases it has been noted of a blackish purple color. The leaf blade resembles that of the Rolliza, but is somewhat shorter. The tuber also resembles that of the Rolliza type.

The "talus soerat" (S. P. I. No. 17239), which was received from the Botanic Gardens at Buitenzorg as *Colocasia monorhiza scripta*, closely resembles the Senteh; however, the striping of the petiole is much less in evidence and the tuber is of a yellowish white color inside and, besides, has a tendency to rise above the soil surface. Both this and the previous variety should be cultivated as ornamentals either in beds or indoors in pots. The yield and quality of the tubers have not been determined.



FIG. 1.—YAUTIAS AND TAROS GROWING AT CAT ISLAND, S. C., SHOWING YOUNG PLANTS IN AN UNFAVORABLE SITUATION.



FIG. 2.—YAUTIAS (S. P. I. No. 17463) FROM HONDURAS GROWING AT GOTH A, FLA., UNDER FAVORABLE CONDITIONS.

S. P. I. No. 20948 resembles the typical Senteh, but has more purplish shading on the lower portion of the petiole. This is one of the most striking varieties of yautia for ornamental purposes.

THE VIOLACEA GROUP.

The two varieties of the Violacea type are very distinct from all other yautias. The entire petiole, with the exception of the extreme distal portion, is of a dark blackish purple, suffused with a glaucous bloom; the leaf blade is normal as to shape, but the color is very dark, while the midrib and larger veins, especially in young leaves, are of a pronounced purplish tinge.

The Guayamera (S. P. I. No. 15394) has been in the trade as *Xanthosoma violacea*. This form was received from the Buitenzorg (Java) Botanic Gardens as *Colocasia antiquorum niger*, and from the Singapore Botanic Gardens as *Alocasia violaceum*. The leaf blade is bent at an acute angle, or at most at a right angle, with the petiole, which stands erect and attains a height of 5 feet. The tubers are rather slender, of medium size, and of a pronounced pinkish or rose color inside. Flowers are almost never seen. Although a very popular variety in Porto Rico, the author never found tubers for sale in the market.

The Prieta, or Morada (S. P. I. No. 15404), is an exceedingly rare variety apparently confined to Porto Rico. It is distinguished from the preceding variety by its leaf blades being at a normal angle instead of nearly vertical, and by its orange instead of rose tubers. This variety, which is of first quality for table use, should be planted in rich, moist soil. It appears to be subject to root troubles if exposed to prolonged drought.

THE PALMA YAUTIA.

It is probable that the Palma yautia (S. P. I. No. 15414) will prove to be botanically distinct from the *Xanthosoma sagittifolium* varieties. The leaf blade, which sometimes measures 4 feet long by 3 feet wide, is strongly concave, like that of most true yautias, but the basal veins of the laminar sinus are much less exposed. The rhizome is caulescent, sometimes rising to a height of 3 or 4 feet above the soil surface. The very small tubers are produced only under very favorable circumstances. However, the large rhizome, which may in one season attain a diameter of 4 or even 6 inches, is used as poultry and pig feed by the natives; for this purpose it should be cut in chunks and boiled. The yellowish or orange interior of the rootstock contains about the same percentage of starch as the Rolliza variety, although the fibro-vascular bundles are more in evidence. Ten pounds is an air weight for a 1-year-old rhizome. This variety fre-

quently flowers, and the spathe (see Pl. IX, fig. 2) is 12 to 18 inches long, rather slender, glaucous maroon below, shading to a pinkish yellow above. The odor is rather unpleasant and pungent. The petiole is shaded from purplish maroon along the sinus to dull-green distad.

THE BELEMBE YAUTIA.

The Belembe (*Xanthosoma hastifolium*), a dwarf species of yautia (S. P. I. No. 15412), is cultivated in Porto Rico and Panama for its leaves, which have an aromatic flavor when boiled. It seldom attains more than 2 feet in height and prefers half shade in moist soil. The petiole is erect, dark green, with a long blade having large, slightly twisted basal lobes. The corm may become multiple-headed from the sprouting of numerous offsets, but no true tubers are ever produced. Only the leaves are utilized. Flowers are sometimes seen.

ALOCASIA VARIETIES.

The *Alocasia* group contains little-known plants whose taxonomic relationships have not yet been worked out. In fact, since they very seldom flower, it is almost impossible to accurately determine their specific names. On account of the insoluble crystals of calcium oxalate (raphides) contained in the cortical portion, or "blanket," of the rhizome, it is not safe to use any of the *alocasias* as table roots or for poultry or stock feeding, although for the latter purpose they can probably be utilized when thoroughly boiled. These plants are of especial utility where a quick-growing root containing a medium quantity of starch is required. In the Tropics, where growth is practically continuous in the moist soils along rivers and mountain streams, 10 to 25 pounds may be calculated as the normal weight for a rootstock of from 1 to 2 years of age. Many of the South American forms which may prove to belong to a closely related genus have the objectionable habit of overstocking.

Among the collection received from Surinam a few forms, like the Abo (S. P. I. No. 19222) and the Koso (S. P. I. No. 19221), have considerable color on the petiole, which frequently shades into a purplish zone about the tip of the rhizome. The leaf blade somewhat resembles that of the Palma yautia, but is more flat, with less prominent veins and a more nearly closed laminar sinus (see Pl. II, A). The color of the interior of the rhizome varies from white to orange.

ALOCASIA MACRORHIZA.

The *Alocasia macrorhiza* is seldom cultivated in Porto Rico, where it bears the common name of Panama, but is frequently used for feeding pigs. The plant is an even, dark, shining green throughout,

FIG. 1.—YAUTIAS GROWING ON A STEEP HILLSIDE NEAR THE ROAD
BETWEEN UTUADO AND ARECIBO, PORTO RICO.



FIG. 2.—FLOWER OF THE PALMA YAUTIA.



though the inside of the rootstock is white. The laminar sinus is practically open, though the basal veins are always covered. Even 9-foot plants have thus far resisted all attempts to shock them into flowering. It is believed that this variety will succeed better as a starch root than even *Alocasia indica* or *A. odora*, though prolonged field tests are necessary to determine this point.

TARO VARIETIES.

Though among the oldest cultivated plants in the world, the fifty to one hundred varieties of taro now in cultivation have received very little scientific attention, and are consequently in a deplorable state of taxonomic confusion. Undoubtedly the larger number of these forms will be found to conform to the limitations of the species *Colocasia antiquorum* and to its principal variety, *C. antiquorum esculentum*. For convenience in cultural discussions we may divide the genus into two groups, viz, the true taros and the dasheens. The petioles and blades of both groups are very similar (see Pl. III). However, the tuberous offsets of the dasheens are seldom found among the true taros, although thickened, stolon-like, and more or less superficial offsets are common under certain circumstances in some of the taro types. The leaf is always peltate, though the angle which the blade forms with the petiole is variable; the comparative width of the blade and its irregular marblings and mottled areas are also inconstant. Among the dasheens a bronze-purplish shading of petiole is a permanent feature, which, taken with its dwarf size and the tubers, renders the two groups readily separable. Among the taros color and markings run rampant; indeed, even the sap of two or three varieties is colored, or at least colors instantly upon exposure to the air.

In Hawaii, where forty-five distinct varieties are recognized, the taros are roughly divided into upland and lowland sorts. Varieties of the latter type are usually flooded at frequent intervals during the growing season (see Pl. X), partly to keep down weeds and partly because the plants require a great quantity of water. Although most taros contain from 15 to 25 per cent of starch, the size of the starch grain itself (see Pl. VI, fig. 1) is so small ($1\ \mu$ to $3\ \mu$) and the gum content of the root is so high that it is doubtful whether any commercial method for extracting the starch from either the taro or the dasheen can readily be found. However, for grinding into flour or meal or for alcoholic distillation roots of both types of this section are eminently adapted. Two or three companies have already placed upon the market a flour made by grinding the cooked roots of some of the Hawaiian taros.

Perhaps the commonest, or at least the most widely distributed, of all the taros is the common West Indian "eddo," or, as it is known

in Porto Rico and Cuba, the "malanga." This variety attains a height of 3 to 5 feet, has comparatively few suckers, and produces in six to ten months a more or less cylindrical or fusiform rhizome from 6 to 12 inches long by 3 to 4 inches in diameter. The leafstalks are pale green, becoming almost white toward the base, although at the point of attachment with the rhizome there is frequently a distinct shade of rose. The leaf blade is bent at a considerable angle with the petiole, so that in the mature leaf it hangs nearly vertical. The rootstock is more or less covered with a fibrous bark similar to that of the yautia root; it has practically no blanket of poisonous tissue about the starchy interior. Not only is there a slight trace of tannin in the mucilaginous juice of the root—which of course becomes black when touched with iron or steel—but it appears to have some ferment which upon cooking changes the juices of the root to a purplish black shade. Hence the boiled taro root has not the inviting white appearance of the yautia tuber upon the table. The fibro-vascular bundles of the rhizome are small as compared with those of the yautia rootstock. The fungous diseases which attack the yautia are also in evidence among the taro and dasheen varieties, although the latter root appears to be much more resistant than the former.

It appears that there are several forms of this typical West Indian taro, which vary in point of color of the petiole base and of the top of the rhizome. The strongest variation from this type, which should perhaps stand in a class by itself, is the highly colored Royal or Lehua taro (S. P. I. No. 19952) of Hawaii. This variety, which was formerly cultivated solely for the royal families, contains a blood-like sap and produces purplish or rose-colored roots; even the veins in the leaf blade are more or less tinged with reddish purple. This is an upland variety requiring comparatively little water, which should be generally cultivated as a first-class table tuber for the fancy-vegetable market.

STRIPED TAROS.

The marblings or stripings of the petiole and the more or less pronounced marbling of the leaf blade in this section of true taros serve to readily distinguish the forms superficially. The shape of the blade varies from the exceedingly narrow and flat form found in a variety from Sibpur, India (S. P. I. No. 17102), to the strikingly striped varieties from Java, like the "talus belang" (S. P. I. No. 20954), which has pale-green petioles entirely covered with more or less irregular bands of bronze-green, while the blade itself is strongly marbled in light and dark green patches. The "talus koekoek" (S. P. I. No. 20953), also of Java, has petioles nearly white, with a slight brownish narrow striping, especially on the young leaf, while

TAROS UNDER CULTIVATION IN WET GROUND NEAR HONOLULU, HAWAII. IN THE LIGHTER AREAS THE PLANTS HAVE NOT YET COVERED THE STANDING WATER.



the sinus wings are involute and the blade a bluish green shade with a weak, slightly crumpled margin. The "kempol koenig" (S. P. I. No. 20945), of Java, has the palish petiole covered over with minute, cross-hatched, darker green lines.

The petiolar spot on the upper surface of the blade varies from a yellowish green to a pronounced purplish shade, which may be en masse or in the form of radiating lines. The color of the roots varies from ivory-white to orange-yellow. In some varieties there is a tendency to produce many offsets.

RED TAROS.

Only ten or twelve distinct sorts of red taros are included in the collection made by the writer, though it is probable that this number could be easily doubled, or perhaps trebled. However, the red or black taros are comparatively rare and until last year were practically unknown in the Western Hemisphere. The colors of the petiole vary from a pale reddish or maroon tinge to an almost black color. Of the latter type, the "kalukandala" (S. P. I. No. 17461) of Ceylon may be taken as a type. This strong-growing and highly ornamental variety holds its nearly erect black petioles 4 to 6 feet high. The rhizome is yellowish inside, while its apex and the bases of the petiole are purplish.

Another type, the "garendakandala" (S. P. I. No. 17459), also from Ceylon, has obscure greenish lines upon a reddish brown background, except toward the upper part of the petiole; the blade narrow, glaucous blue; the top of the rhizome and extreme base of the petiole white instead of pink.

Another distinct type is the "kiempol poetich" (S. P. I. No. 20947) of Java. In this the petiole is bronze-red in the middle, pale green at the base and apex, with a paler, involute sinus margin. The blade is peculiar in having purple flecks near the petiolar spot and occasional pale-green blotches near the middle, while the veins are dark glaucous green.

DASHEEN VARIETIES.

For reasons previously explained, it is not always easy to distinguish between the dasheens and the taros, for some of the dasheens have a tendency to throw sprouts from the tips of the tubers, while some of the taros produce tuber-like offsets at the surface of the ground. Many forms of the dasheen have been cultivated in China and Japan for centuries, if not for thousands of years. One variety, the Hatake-imo (S. P. I. No. 21649) of Japan, has the corm-like offsets combined into a multiple-headed clump; but, stranger still, each tip throws out not one but an indefinite number of buds. It is possible that the process of close cutting the petiole has finally brought about an abnormal habit in this form. The leaf and petioles

of this variety in particular, and of many of the so-called "imos" of Japan in general, are gathered as greens and boiled like spinach, and they are also dried and preserved with salt.^a

A distinct type of dasheen which was sent under the name *Leucocasia gigantea* (S. P. I. No. 21644), the Hasu-imo of Japan, is so free from the acidity which is common in the vegetative portion of these plants that the petioles may be eaten even without cooking. The color of the petiole varies from a pale green in some of the Japanese forms to a pronounced purplish bronze color; the petiolar spot may be obscure or purplish, as in the taros.

Perhaps the best form of dasheen is the Trinidad (S. P. I. No. 15395). This matures its tubers in about six months from planting, provided the soil and climatic conditions are favorable. Though the tubers are not large (seldom larger than a hen's egg), the prolificness makes up for the small size. Both the tuber and the central root-stock may be used on the table; the inside is very white, though the surface is covered with a mat of coarse, reddish brown fibers. The erect petioles are purplish bronze-green, especially in the middle, while the leaf blade is dark bluish green, with a purple petiolar spot. This variety readily adapts itself to either dry or moist soils, provided they are not baked or acid. Since this variety endures close planting, it is probably possible to obtain upward of 10 tons of roots to the acre with common culture in ordinary soil.^b

SUMMARY.

There is a vast area of semicultivated and uncultivated land in the Gulf and South Atlantic States which is too wet to admit of the cultivation of general crops, but which is adapted to the root crops discussed in this paper.

The four types of these root crops, namely, yautias, aloccasias, dasheens, and taros, are practically new to the agriculturists of America, although most of the varieties discussed here have been under cultivation in other countries for centuries.

^a The Midsu-imo (S. P. I. No. 21647), one of the largest tubered of the Japanese dasheens, has yielded in rich, moist soil in an experimental plantation of 35 hills at Gough, S. C., 8½ pounds of roots to the hill. The hills were at a distance of 3 feet, in rows 4 feet apart, and on this basis the yield was at the rate of more than 15 tons to the acre. The length of season was seven months from planting to harvest. Closer planting, which would be of advantage from a cultural standpoint, would probably increase the yield per acre.

^b The Trinidad dasheen yielded in the experiment at Gough, S. C., in a small plot of 6 hills, an average of 7 pounds to the hill, or at the rate of more than 12½ tons to the acre. A somewhat similar variety from Surinam, the "Sinesie," of which 62 hills were grown, yielded an average of 7.6 pounds to the hill, or at the rate of 13½ tons to the acre. Some other varieties of this type, of which only small plots were grown, yielded at a much higher rate.

These crops require only a moderate amount of attention, but under ordinary conditions it is believed that their yield will be comparatively large. Fertilizers are seldom required; insect and fungous pests are comparatively few; cuttings of the root instead of seeds are employed in propagation.

Many of the varieties are of use as salad plants, though the prime object, especially of the yautia and dasheen varieties, is the production of starch. The tubers of many varieties are suitable for table use, and the roots of nearly all forms may be used as stock food either fresh or when ground into meal. Several varieties which produce small but numerous tubers are particularly adapted for the production of alcohol.

II.—AGRICULTURAL HISTORY AND UTILITY OF THE CULTIVATED AROIDS.

By O. F. COOK.

There can be no question as to the importance of the cultivated aroids. Though a large number of varieties, and even distinct species and genera, are included under this general term, the series may be viewed agriculturally as a single crop of world-wide importance. It is unfortunate that the studies reported upon by Mr. Barrett could not be carried farther, but even this incomplete report contains a very much wider range of information than any other publication on the subject.

The culture of the taro extends from the West Indies across the Pacific islands, Japan, China, the Malay region, Hindustan, Madagascar, and the whole breadth of tropical Africa. The natives of East Africa grow the taro extensively and have many named varieties.^a Welwitsch reports *Colocasia* as growing spontaneously in the Portuguese colony of Angola, even in districts where it is not now used by the natives. The taro exists also among the natives of the interior of Liberia, though the eddoes (*Xanthosoma*), introduced from the West Indies in the last century, are now preferred.

The scientific name *Colocasia* has been connected through the Greek with an ancient Egyptian word, "culcas." The taro is cultivated in Egypt, but its antiquity in that country was questioned by De Candolle, who also doubted whether "culcas" was really the name of the plant that we now call *Colocasia*. I have recently learned from Mr. A. Aaronsohn that the taro is grown in Palestine and Syria, especially in the vicinity of Beirut, and that the word "culcas" is still in use among the Arabs as the name of the plant. Mr. Aaronsohn is also inclined to believe that the culture of the taro in Palestine is very old.

The culture of the taro in China is considered by all authorities as very ancient. The Chinese residents of California import con-

^a Dammer, U. Die Gemüsepflanzen Ostafrikas. In Engler's Die Pflanzenwelt Ost-Afrikas und der Nachbargebiete, Berlin, 1895, p. 131. The presence of a variety of *Xanthosoma* among the cultivated East African aroids is indicated, though the plants have not been thoroughly studied.

siderable quantities of taro from Canton and from Hawaii, and are beginning to produce it in California. There is also said to be a growing demand for it among the white population.^a

Whether the taro also existed in ancient America and thus had a really world-wide distribution in prehistoric times is an interesting question worthy of a careful investigation from the standpoint of ethnology as well as from that of the agricultural study of the varieties. The fact that these cultivated aroids have been so persistently neglected by Europeans lends them an especial interest in the study of primitive agriculture, since we have much greater justification for supposing that their distribution represents the work of primitive man than in the case of plants in which civilized people have been interested. The present tendency to give more careful consideration to such plants and to exchange varieties between remote parts of the world is likely to disturb the present localization of varieties and make it even more difficult to learn their source unless careful studies of the varieties accompany the work of introduction.

There seems to be no record of an introduction of the taro into America by Europeans until very recent times, and yet botanists have reported it as existing in many localities among the natives. The close external similarity of the taro to the yautia renders it very probable that mistakes would be made and prevents our placing any complete reliance upon the reports, even of acknowledged authorities, unless we can know the facts on which their identifications were based. Thus Seemann, who was an eminent and thoroughly competent botanist, reported the existence of *Colocasia* in Panama with the native name *otó*, while Mr. Barrett reckons the *otó* as one of the varieties of *Xanthosoma*. Varieties having leaves with a closed sinus are reckoned as *Colocasia*, those with a completely margined open sinus as *Alocasia*, those with the margin interrupted in the sinus as *Xanthosoma*. These leaf characters are certainly very convenient in dealing with these varieties that seldom or never flower, but it has to be admitted that such differences are often found among members of the same genus in other groups of plants. The forms reckoned as *Xanthosoma* appear to be more different among themselves than some of them are from varieties placed in *Colocasia*. Thus the Palma yautia is very distinct from the other Porto Rican varieties. Its failure to produce tubers, ready production of flowers (Pl. IX, fig. 2), and greater similarity to a species that grows wild in Central America indicate a more recent domestication.

Varieties of aroids with the taro-like leaves are widely distributed among the natives of the West Indies and adjacent parts of the con-

^a Blasdale, Walter C. A Description of Some Chinese Vegetable Food Materials and Their Nutritive and Economic Value. Bulletin 68, Office of Experiment Stations, U. S. Dept. of Agriculture, 1899, p. 13.

continent, although not nearly so popular in cultivation as many of the varieties of *Xanthosoma*. In Porto Rico and Cuba the taro retains the supposedly indigenous name "malanga," which would hardly be the case if it had been introduced by the Spaniards. If the natives of the Caribbean region considered it superior to *Xanthosoma*, it might be thought to have spread amongst them since the discovery, but it is more difficult to understand the wide distribution without popularity, unless we suppose that the taro was formerly more popular than at present and is being displaced by *Xanthosoma*. If the taro was not already in America before the arrival of Europeans it seems more likely to have been introduced from Africa than from the Pacific islands. Importers of slaves from Africa found it to their advantage to supply the negroes with their accustomed foods. The African oil palm and the cola nut, as well as certain varieties of sweet potatoes and yams, are supposed to have been established in the West Indies during the period of the slave trade. The name "malanga" itself is similar to many African words. One of the East African names of the taro is "malombo."

If it be true, as Mr. Barrett seems to think, that *Alocasia* as well as *Colocasia* has numerous American varieties, it becomes reasonable to suppose that the three principal types of cultivated aroids, *Xanthosoma*, *Colocasia*, and *Alocasia*, were originally domesticated in America. The American nativity of *Xanthosoma* has not been questioned, but the greater importance of *Colocasia* and *Alocasia* among the Polynesians has made it appear that they must have originated in the Pacific islands or the Malay region. The same argument has been applied to the coconut palm, which is certainly a native of America, though it has usually been ascribed to the shores of the Pacific and Indian oceans because of its much greater importance in the East Indies than in the West.

The domestication of root crops characterized an early epoch in the development of primitive agriculture in tropical America. This is shown by the large series of root crops that were domesticated in America. In addition to the cultivated aroids, there were sweet potatoes (*Ipomoea*), arrowroot (*Maranta*), cassava (*Manihot*), yams (*Dioscorea alata*), apio (*Arracacia*), lleren (*Calathaea*), potatoes (*Solanum tuberosum*, *S. commersoni*, and other species), ullucus (*Ullucus tuberosus*), achira (*Canna edulis*), masua (*Tropaeolum tuberosum*), oca (*Oxalis crenata*), and the Jerusalem artichoke (*Helianthus tuberosus*). The yam bean or jicama (*Pachyrhizus*) and the chayote (Chayota or *Sechium*) were also grown as root crops, though propagated from seeds.

In addition to this series of plants that have become known as root crops and are usually mentioned as such in botanical works of reference, there are records of several other species that are planted

as root crops in South America. A list of these has been collected recently by Prof. H. Pittier, of the Bureau of Plant Industry, including *Polymnia edulis*, *Lepidium meyenii*, *Portulacca grandiflora*, and several other plants whose botanical names and agricultural possibilities are still unknown.

The root crops that were domesticated in America stand in distinct contrast with Old World root crops, both in number and in character. The species cultivated in the Old World were relatively few, mostly the seed-propagated garden vegetables of temperate regions, such as radishes, turnips, beets, parsnips, carrots, etc. The temperate root crops domesticated in the Old World were mostly capable of being eaten raw, as though they had been used first by people unaccustomed to use fire for cooking vegetables. The root crops that were domesticated in America are not eaten raw by the natives. Many of them are disagreeably acrid in the raw state, like the aroids, or even positively poisonous, like the cassava. Very few new types of plants appear to have been domesticated as root crops in the Old World Tropics, and none of them have attained the prominence of several of the American species. The banana appears to have been domesticated first as a root crop, and some of the varieties are still cultivated for their rootstocks in New Caledonia and in East Africa.

The greater antiquity of the domestication of plants in America is to be inferred from the fact that many of the cultivated species are not known in the wild state, while in the Old World there are very few species, if any, that do not have wild representatives that still appear closely similar to the domesticated forms. In the case of the yautias the American nativity is clearly indicated by the wild species of *Xanthosoma*. One of these grows abundantly in Guatemala and is eaten by the natives in times of scarcity of other food. Yautias are also cultivated in Guatemala, but rather sparingly, Indian corn being the chief staple in all parts of the country. The varieties of *Xanthosoma* cultivated in Guatemala appear quite distinct from the common wild species. The wild plant is larger and has a lighter green foliage, and the rootstocks that provide for the vegetative propagation of the plant are very slender, only about the diameter of an ordinary lead pencil, instead of the large, fleshy, tuberous rootstocks produced by the cultivated sorts. This wild species has a considerable similarity to the variety cultivated in Porto Rico under the name "yautia palma," but has a shorter and thicker spadix with a less ample spathe.

The abundance of the wild xanthosomas in the mountainous parts of Guatemala, including the volcanic districts, makes it easier to understand how a poisonous plant might come to be used and finally

protected, propagated, and cultivated by primitive man. The agricultural development would come about very naturally and gradually after the making of the simple discovery that these acrid plants could be eaten after they had been kept for a time in boiling water. This discovery was possible in many places in tropical America in the very early stages of human progress, before cooking utensils were used and even before fire had been definitely adopted by primitive man. Springs of hot water are numerous and are shown by special abundance of ancient remains to have been centers of population in primitive times. Former association with hot springs is also suggested by the habit of many of the Indians, such as the Kekchis of eastern Guatemala, to drink only hot water.

An alternative possibility has to be admitted, that the taro plant, like the banana, might have been brought to America from the Pacific islands in prehistoric times and might have fallen into comparative disuse as the result of the discovery in America of the *xanthosoma*, which seems to be a better plant for general agricultural purposes. There is good historical evidence that the banana, which certainly originated in the Old World, had been brought to America before the Spanish conquerors arrived. No such direct testimony is likely to be secured regarding the taro, which attracted relatively little attention from the early historians of Spanish America. We have to rely upon the general considerations that it is not likely to have been brought by the Spaniards, and still less likely to have been adopted by the Indians, who are very slow to take up the cultivation of any new plant unless it appears to have a very distinct advantage. The Polynesian method of cultivating the taro in pools or swamps is not known to be applied to the plant anywhere in America. Mr. David Fairchild, of the Bureau of Plant Industry, states that the Polynesian system of planting the taro in the muddy soils of swamps or artificially flooded places is in use in the island of Madeira, introduced, doubtless, by the natives of the island who have lived in Hawaii (see Pl. X). The nearest approach to this system is seen when the plants are scattered along the banks of small streams. Many yautias are raised in Porto Rico on very steep, rocky slopes of mountains, where the soil is very shallow and irrigation is quite out of the question. (See Pl. IX, fig. 1.)

Whether or not we agree with Mr. Barrett regarding the prospective commercial importance of the aroids or their profitable cultivation in the United States, the study of them is eminently justified by two practical considerations, (1) that they are extensively used as food by millions of natives of tropical countries and (2) that they are worthy of much more careful consideration by all Europeans who undertake to settle or reside in tropical countries.

The Tropics afford a great variety of fruits, though there are few localities where the traveler's expectations of profusion are realized. But if fruits are usually to be reckoned as scarce, there is often a downright famine of vegetables. Not only on the Isthmus of Panama, but in many other parts of the Tropics where railroad building and other improvements are being attempted by men from Europe and the United States, the deficiency of fresh vegetables is recognized as a practical difficulty which seriously interferes with comfort, health, and efficiency.

The Department of Agriculture receives many letters from American residents of tropical countries asking for information and seeds of varieties of temperate vegetables that will grow in the Tropics. In some regions moderate success with a few of the temperate types of vegetables is possible if special care is used and after sufficient experience has been accumulated. Varieties better suited to tropical conditions are being discovered or introduced from other tropical countries. The success of the Chinese gardeners with some of their seeds from Canton shows that their varieties and methods of culture are worthy of our careful consideration.

In many cases the most practical advice that can be given to persons newly established in tropical localities is to study and make use of the indigenous tropical vegetables, of which these yautias, taros, etc., form excellent representatives. These plants will thrive and produce abundantly under extreme tropical conditions where most of our temperate vegetables will refuse to grow and the others can be expected to produce only the most indifferent results. The acrid substances and milky secretions render the aroids immune to many of the diseases and insect pests that interfere with the cultivation of other kinds of plants that lack such protection.

Propagation by rootstocks is an especial advantage under tropical conditions, since it avoids the difficulties of germinating, transplanting the seedlings, and caring for the plants in their tender early stages. With sufficient water the cultivated aroids may be expected to hold their own with any other crop, and they will also thrive in places too wet for most of our cultivated plants.

The agricultural advantages make it all the more desirable that residents in the Tropics should become thoroughly acquainted with the cultivated aroids. Many people think they have tried the tropical vegetables who have not really done so. It is necessary to learn how to use a new plant, as well as to learn how to grow it, and one must persist until he has had a fair opportunity of testing his own taste. The tendency to condemn any unfamiliar dish is very general, whereas the same flavor that seemed so objectionable at first may appear quite attractive after we have become accustomed to it.

This is true of the aroids used as garden vegetables. By people who have become familiar with yautias or eddoes they are often recommended as better than potatoes. But if one expects too close a similarity he is disappointed. Instead of the soft, mealy, white, bland-tasting "mashed potato," one finds a much firmer material of a somewhat yellowish or grayish color and a distinct, slightly nutty flavor. Nobody would be likely to mistake eddo for potato, and if potatoes were expected eddoes might be a distinct disappointment. But if we give the eddo a fair trial on its own merits, it may hold its own with the potato in our gastronomic affections. We may be surprised to find ourselves as willing to have eddoes served as potatoes or to find that we miss the eddoes at home as much as we did the potatoes in Africa.

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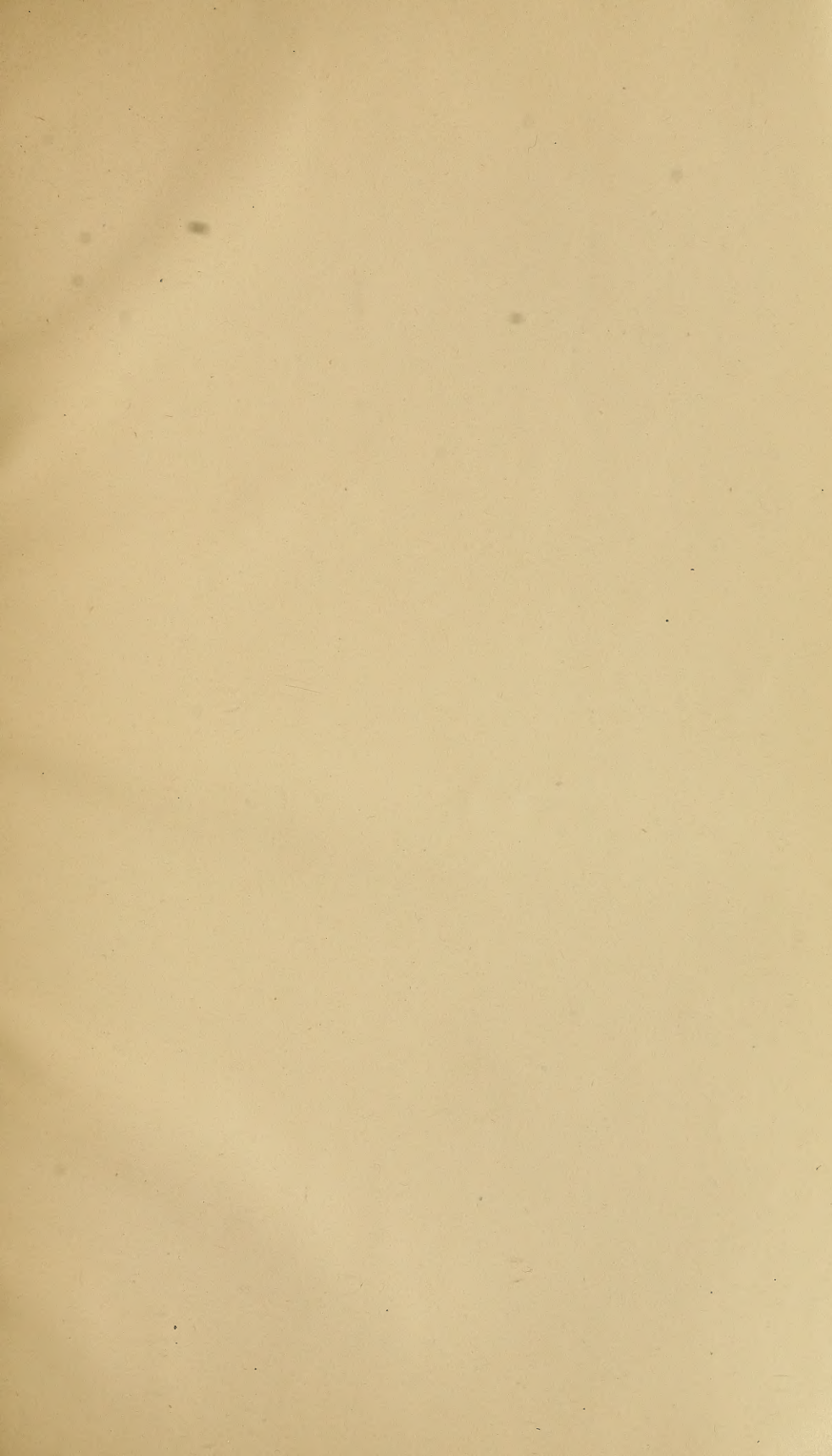
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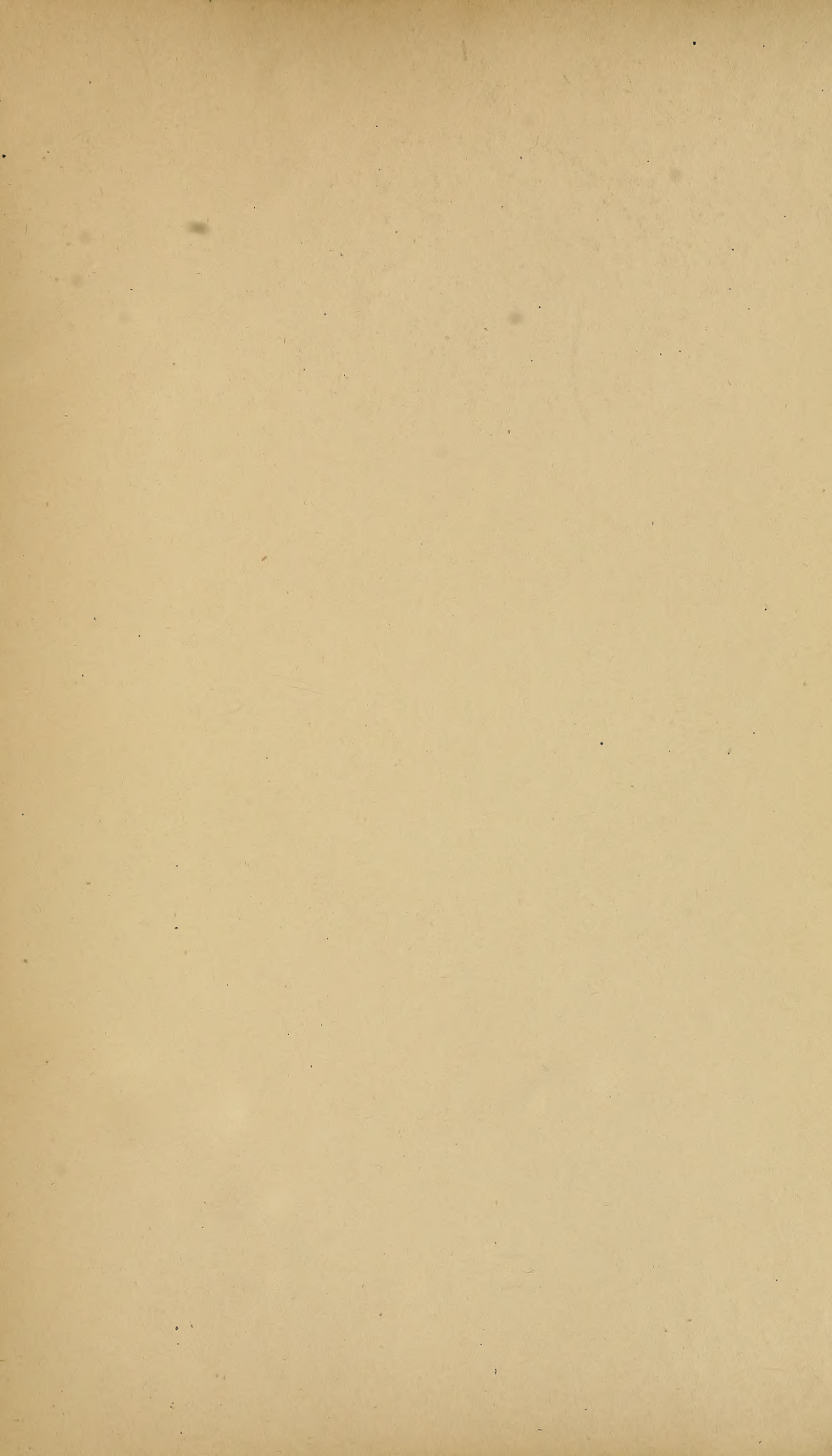
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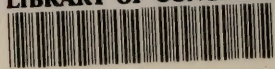
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